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ENVIRONMENTAL ASSESSMENT

MODIFICATION OF WHITMORE VILLAGE WASTEWATER TREATMENT PLANT WHITMORE VILLAGE, OAHU, HAWAII

Prepared for:

OCEANIC PROPERTIES
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CHAPTER ONE
INTRODUCTION

PURPOSE

The intent of this environmental assessment is to provide the City and County of Honolulu, *Division of Wastewater Management*, with the information necessary to determine whether proposed modifications at the Whitmore Village Wastewater Treatment Plant (Whitmore WWTP) will generate any significant environmental effects. This information is being provided by Oceanic Properties to supplement its wastewater treatment plant proposals for the Whitmore Village Wastewater Treatment Plant. These proposals have been developed by Oceanic Properties, Inc. as part of its commitment to participate in the cost of treating future wastewater flows from its Kahi-Kani Subdivision project.

SCOPE OF THE ENVIRONMENTAL ASSESSMENT

Information and analyses presented in this environmental assessment were made to conform to the content requirements outlined in Title 11, Chapter 200 of the Hawaii Revised Statutes. Section 10 of Chapter 200 requires that environmental assessments contain, at least, the following information:

1. identification of the applicant;
2. identification of the approving agency, if applicable;
3. identification of the agencies consulted in preparing the assessment;
4. general description of the proposed project's technical, economic, social, and environmental characteristics;
5. summary description of the affected environment, including location and site maps;
6. identification and summary of major impacts and alternatives considered, if any;
7. proposed mitigation measures, if any;
8. an approving agency, e.g., City and County of Honolulu, determination and reasons supporting the determination; and
9. agencies that should be consulted if a more detailed environmental impact statement is required.

With the exception of determination and consultation requirements of the City and County of Honolulu, Division of Wastewater Management, this environmental assessment includes information and analyses that address all other general content requirements.

This environmental assessment gives particular attention to the anticipated volume of influent to Whitmore WWTP and the quality of wastewater effluent. The potential impact of the treated effluent discharge upon the water quality, fish habitat, and fisheries management of Wahiawa Reservoir is also addressed.

REPORT ORGANIZATION

The environmental assessment document is organized in the following manner.

Chapter One identifies the purpose, scope and organization of the environmental assessment; related research methods; and those responsible for the preparation of the environmental assessment.

Chapter Two discusses selected planning issues, identifies three development options and costs, compares the three project alternatives, and identifies the recommended project development option.

Chapter Three evaluates the significant characteristics and trends influencing the operation of the Whitmore Village Wastewater Treatment Plant, land uses in the Whitmore Village area, as well as the fishery and water resources of the Wahiawa Reservoir.

Chapter Four analyzes the anticipated environmental consequences of the proposed project. Significant impacts are quantified, to the extent practical, to facilitate reviewers assessment of anticipated project impacts. Feasible mitigation measures, that may reduce anticipated project impacts, are also identified.

METHODOLOGY

A combination of quantitative and qualitative analyses were used in the preparation of this environmental assessment. These evaluations relied primarily upon information that was made available by public agencies such as the City and County of Honolulu, Division of Wastewater Management; State Department of Health; University of Hawaii, Water Resources Research Center; and the State Department of Land and Natural Resources, Division of Aquatic Resources. Available information from public and private organizations was obtained through the use of existing technical reports and supplemented by discussions with selected representatives of these and other agencies.

Wastewater design criteria, plans, and related information concerning the proposed Whitmore WWTP modifications was obtained from Belt Collins & Associates, Inc. This information was supplemented by an independent analysis of the proposed plant modification design, as well as existing Whitmore WWTP operations. This analysis was made by Mr. Dennis M. Reid, P.E., consulting water and wastewater engineer.

AGENCY AND PUBLIC CONSULTATION

Preparation of this environmental assessment involved consultation with the following public and private organizations:

City and County of Honolulu
  Division of Wastewater Management

State of Hawaii
  Department of Health, Clean Water Branch
  Department of Land and Natural Resources, Division of Aquatic Resources

Private Organizations
  Oceanic Properties, Inc.

RESPONSIBILITY OF ENVIRONMENTAL ASSESSMENT PREPARATION

This environmental assessment was prepared by James H. Pedersen, Planning Consultant, at the request of Belt Collins & Associates, Inc. Belt Collins & Associates is a well-known planning and engineering consultant organization that provides planning, design and construction management services to public and private agencies throughout the Pacific Basin.

Mr. Jim Pedersen is a planning consultant with 19 years of professional experience associated with the evaluation and master planning of regional, community and site development projects throughout the Pacific Basin. These projects have involved his management and preparation of regional economic and infrastructure development plans; community development and redevelopment projects; economic and development feasibility studies; site and facility plans for specific transportation, residential, commercial and industrial development projects; and the preparation of related environmental impact evaluations.

CHAPTER TWO
PROJECT ALTERNATIVES

BACKGROUND PLANNING ISSUES

Introduction

Two planning issues primarily influenced the selection of development options for this project. These issues include: 1) increasing wastewater flows from the Whitmore Village area; and 2) water quality, fish habitat and fisheries management within the Wahiawa Reservoir and Kaukonahua Stream. These issues are discussed in the following paragraphs.

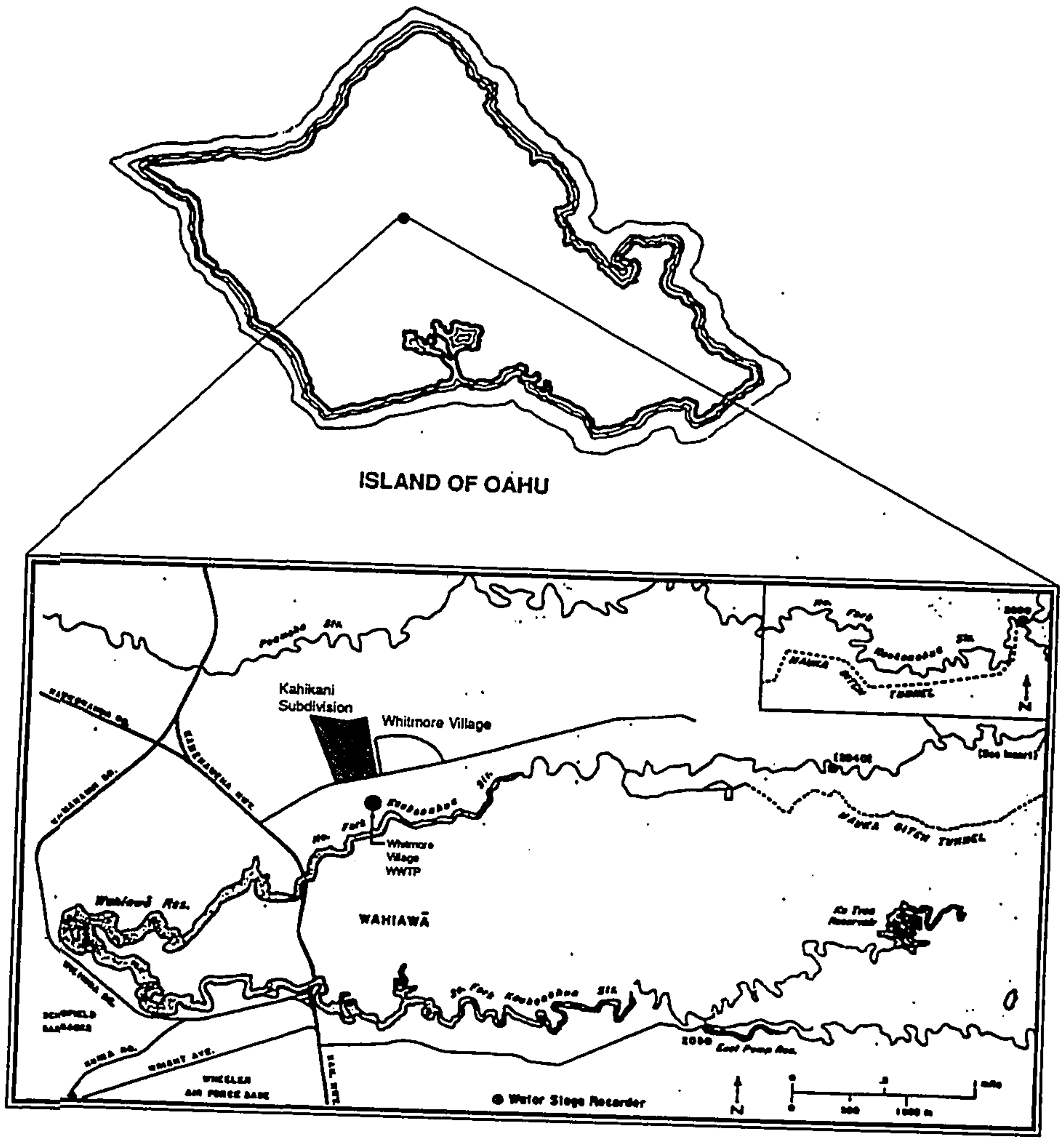
Other secondary considerations, e.g. National Pollutant Discharge Elimination System (NPDES) permit requirements, are relevant to the evaluation of the proposed project. However, these evaluations are more appropriately presented in Chapter Three.

Increasing Wastewater Flows in the Whitmore Village Area

The Whitmore Village Wastewater Treatment Plant (Whitmore WWTP) is presently being operated by the City and County of Honolulu, Division of Wastewater Management, near the plant's original design capacity of 0.2 million gallons per day (mgd). An estimated resident population of 3,352 persons (Ng, 1989) currently generates average wastewater flows of approximately 0.16 mgd to the plant, or approximately 48 gallons per capita per day. This includes Phase I of the Kahi-Kani Subdivision project.

For design and operational purposes, the City and County of Honolulu, Division of Wastewater Management, assumes a per capita generation rate of 60 gallons per day in order to ensure that the present plant can accommodate peak flows. Consequently, the Division of Wastewater Management assumes that the existing Whitmore Village population contributes approximately 0.201 mgd, or 100 percent of the plant's treatment capacity.

A significant factor influencing the future operation of Whitmore WWTP is the ongoing development of Kahi-Kani subdivision located on the west side of Whitmore Village (Figure 2-1). This project is being developed by Oceanic Properties, Inc. and being constructed by Mililani Homes, Inc. Phases II, III and IV of this subdivision are expected to connect 214 additional housing units to the Whitmore Village sewage collection system. The City Division of Wastewater Management assumes an occupancy rate of four persons per household. Using this assumption, this future population could generate an additional 0.051 mgd of wastewater flow.



PROJECT LOCATION MAP

FIGURE 2-1
REGIONAL LOCATION OF
WHITMORE VILLAGE WWTP

Representatives of the City Division of Wastewater Management indicate that existing zoning could permit the development of some 50 additional Ohana dwellings in the Whitmore Village area (Figure 2-2). However, the Division could deny sewer connection rights to these Ohana residential units on the basis of inadequate wastewater treatment plant capacity. Consequently, the potential flow from these housing units is not considered to be a portion of the anticipated wastewater flow to Whitmore Village WWTP.

Water Quality, Fish Habitat, and Fisheries Management in Wahiawa Reservoir and Kaukonahua Stream

Water quality studies of the Wahiawa Reservoir have been conducted by the University of Hawaii's Water Resources Research Center (WRRC), most notably during the 1976-1981 period. WRRC Technical Report No. 89 (Young et al, 1975) summarizes analyses of the impact of secondary effluent, from the Wahiawa and Whitmore wastewater treatment plants, upon the water quality of the Reservoir. Dr. Young, and other co-investigators from the WRRC, concluded, in part, that:

1. higher nitrogen and phosphorus levels are present in the Reservoir during lower water level periods;

2. Wahiawa and Whitmore Village WWTP contribute roughly 75 percent of the nutrient input to the Reservoir; however, Whitmore Village WWTP provides only two percent of the nitrogen input and eight percent of the phosphorus input;

3. the cumulative impact of sewage effluent discharge into Wahiawa Reservoir is its effect on dissolved oxygen (DO) levels;

4. ***"...sediment quality indicates a definite eutrophic condition downstream of the treatment plant discharges";***

5. algal growth studies indicate that ***"....nitrogen may be the limiting growth factor for waters near the surface, and phosphorus for deeper waters downstream of the treatment plant discharges";***

6. Wahiawa and Whitmore wastewater treatment plants should incorporate the use of tertiary treatment for the removal of phosphorus from sewage effluent being discharged into the Reservoir.

The study investigators also concluded that tertiary treatment would only be needed during low flow conditions within the Reservoir. Higher flow conditions permit a greater dilution which reduce phosphorus levels in the Reservoir.

State aquatic resource biologists believe that the most serious consequence of the nutrient loading is phytoplankton production.

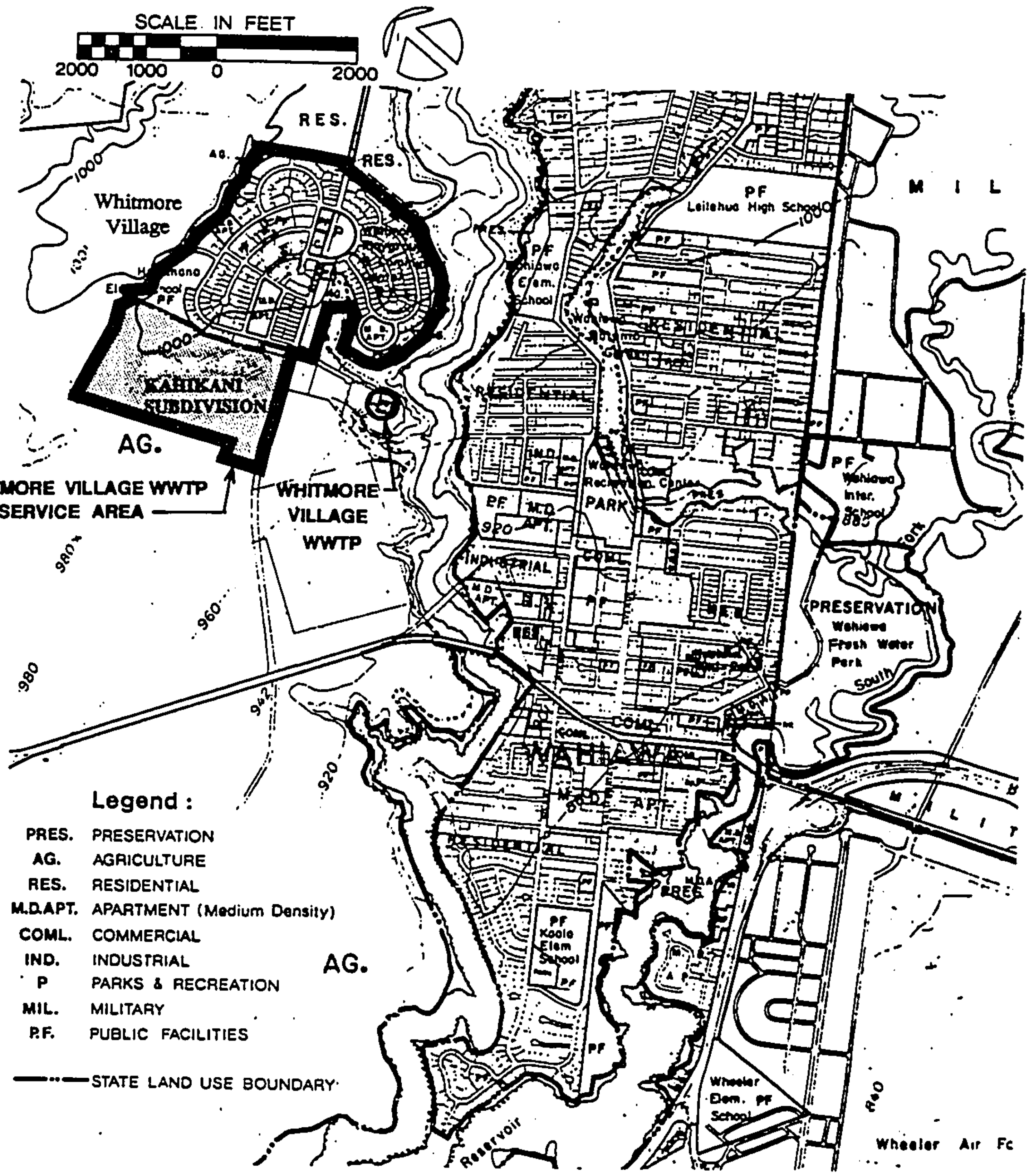


FIGURE 2-2
WHITMORE VILLAGE AREA MAP

"During the warmer periods of the year, the normal green coloration of the water intensifies dramatically near the Wahiawa Sewage Treatment Plant outfall. The increased phytoplankton production produces a net excess of oxygen, most of which is lost to the air, and the huge fish population" (Paty, 1989).

Supersaturated concentrations of dissolved oxygen are present during the summer months when Reservoir water levels are typically higher. However, during periods of lower water levels later in the year, fish survival is "threatened" by changing weather conditions and significant decreases in dissolved oxygen levels (Paty, 1989).

Ultimately, significant variations in dissolved oxygen create an imbalance in the Reservoir fish population, specifically the ratio between predator and forage fish species. This imbalance poses a management problem to the State Division of Aquatic Resources which has responsibility for the management of public fresh-water fishing activity in the Wahiawa Reservoir.

Consequently, the water quality of Wahiawa Reservoir is influenced by the nutrient loading generated by sewage effluent discharges, principally the Wahiawa WWTP. The nutrient loading is compatible with the primary use of the Reservoir as an irrigation storage facility. However, the recreational fishery is affected by significant DO variations caused by significant water level changes, nutrient loading from sewage effluent and urban runoff, the seasonal variation in fresh-water input, and other related factors.

DEVELOPMENT OBJECTIVES

The development objective of Oceanic Properties, in cooperation with the City Division of Wastewater Management, is to accommodate existing and anticipated domestic wastewater flows to the Whitmore WWTP. The combined flows will represent a total flow of 0.211 mgd.

DEVELOPMENT OPTIONS

Introduction

Three feasible options for accomplishing the development objective include:

Alternative A - Pump increased wastewater flows over 0.2 mgd to the Wahiawa wastewater treatment plant (Wahiawa WWTP), and provide no additional treatment at Whitmore Village WWTP;

Alternative B - Pump all Whitmore Village (including future Kahi-Kani subdivision) wastewater flows (0.211 mgd) to the Wahiawa WWTP, and provide no additional treatment at Wahiawa WWTP;

Alternative C - Expand capacity of the existing Whitmore WWTP facility to 0.211 mgd by modifying existing operations and portions of the existing facility.

The "no-project option" is not considered to be a viable project alternative since the City and County of Honolulu has already approved Phases I, II and III of the Kahi-Kani subdivision project. The construction of all homes, and the installation of related utility connections, e.g., the sewage collection system, for Phase IV of the project is already in progress and scheduled to be completed by late 1990.

The scope of project alternatives A, B, and C are presented more fully in the following paragraphs.

Project Alternative A

Under this option, Whitmore Village WWTP (Figure 2-3) would operate at full capacity and treat 0.20 mgd of domestic wastewater. The additional wastewater flows (0.051 mgd), generated by future residents of Kahi-Kani Subdivision (Phases II, III and IV), would be transported to Wahiawa WWTP via a 12-inch gravity sewer line along Whitmore Avenue to Kamehameha Highway (Figure 2-4). A new pump station would be constructed along Kamehameha Highway that would lift sewage across Karsten Thot Bridge through a ten-inch force main. A connecting 18-inch relief sewer along Kilani Avenue would ultimately transport the additional flows to the Wahiawa WWTP (Kwock Associates, Inc., 1988).

The Whitmore Village Small Community Facility Plan indicates that the Kilani relief sewer will be inadequate to transport year 2010 flows. The existing 18-inch line will need to be replaced by a 24-inch sewer line to accommodate the diverted flows from Whitmore Village (GMP Associates, Inc., 1985).

The cost of constructing this development option has been estimated by Kwock Associates, Inc., to be approximately $1.2 million (Belt Collins & Associates, 1988). Oceanic Properties, Inc. would pay a portion of the overall project design cost.

Project Alternative B

This option would divert the treatment and disposal of all wastewater flows (0.211 mgd) from the Whitmore Village area to the Wahiawa WWTP. Sewage flows from Whitmore Village area would be transported to Wahiawa WWTP via a 12-inch gravity sewer line along Whitmore Avenue to Kamehameha Highway (Figure 2-4). A new pump station would be constructed along Kamehameha Highway that would lift sewage across Karsten Thot Bridge through a ten-inch force main. A connecting 18-inch relief sewer along Kilani Avenue would ultimately transport the additional flows to the Wahiawa WWTP (Kwock Associates, Inc., 1988).

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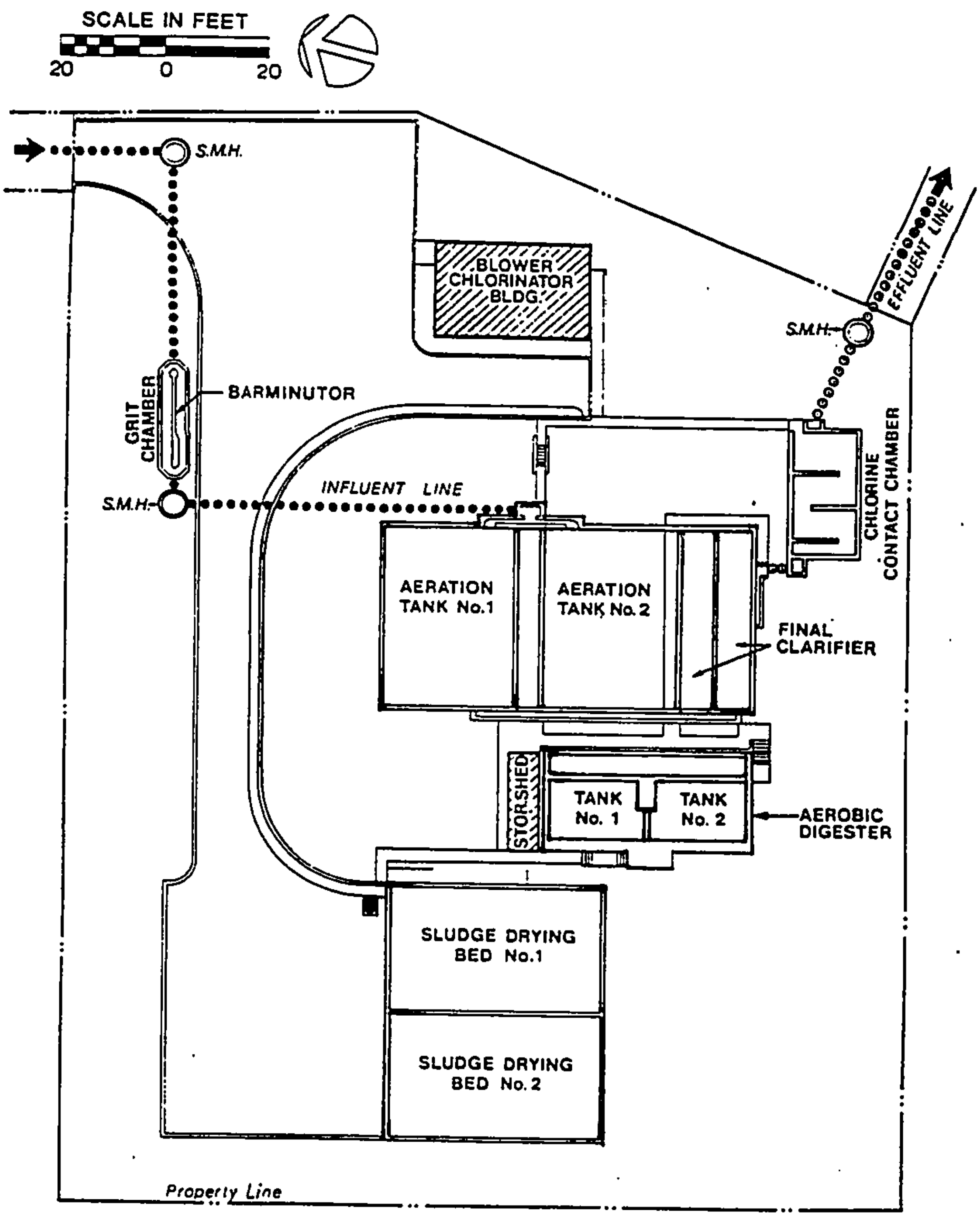

FIGURE 2-3
SITE PLAN
EXISTING WHITMORE VILLAGE WWTP

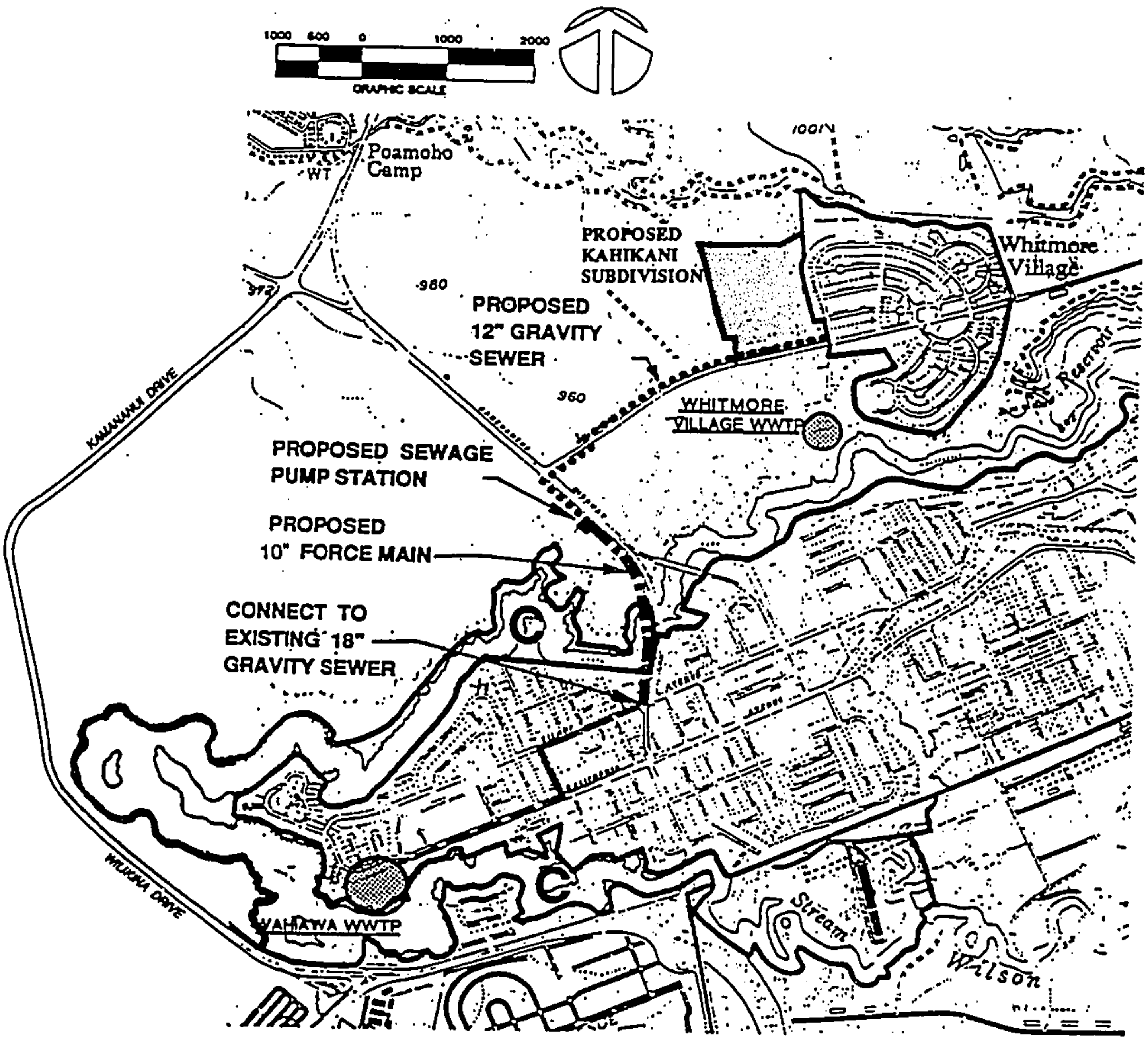

FIGURE 2-4
PROJECT "ALTERNATIVES A & B"
DIVERSION OF SEWAGE FLOWS
TO WAHIAWA WWTP

replaced by a 24-inch sewer line to accommodate the diverted flows from Whitmore Village (GMP Associates, Inc., 1985).

The development cost of this option has been estimated to be approximately $1.2 million (Kwock & Associates, Inc., 1988). Similar to Project Alternative A, Oceanic Properties, Inc. would finance a portion of the overall project design cost.

Project Alternative C

Project Alternative C involves the treatment of all existing and anticipated wastewater flows from the Whitmore Village area (0.211 mgd) via the Whitmore Village WWTP. This alternative involves the installation of four new clarifier tanks (Figure 2-5). City wastewater treatment plant operators at Whitmore Village WWTP will supplement the new plant equipment by incorporating the use of chemical polymers in the treatment process. The use of polymers would be made to facilitate the settleability of sludge in the treatment process. In a cumulative sense, the proposed facilities and modification in plant operations will be installed and made to accommodate an increased wastewater flow at Whitmore WWTP without sacrificing the quality of wastewater effluent being discharged into Kaukonahua Stream.

The cost of implementing this development option is estimated to be approximately $690,000. Almost half of this cost ($340,000) would include the cost of procuring chemical polymer solution over a four-year period. The remaining $350,000 would be used for the installation of new clarifiers within the Whitmore Village WWTP.

Under this option, the City and County of Honolulu would incorporate the use of chemical polymers in the wastewater treatment process. Oceanic Properties, Inc. would install and bear the cost of installing all plant modifications at Whitmore Village WWTP.

COMPARISON OF PROJECT ALTERNATIVES

General

The evaluation of significant environmental consequences made for this environmental assessment indicate that the three project alternatives primarily vary in terms of development cost and the potential impact upon the water quality, fish habitat and fisheries management of Wahiawa Reservoir and Kaukonahua Stream.

Development Costs

The variable costs of each of the three project alternatives are presented in Table 2-1. Estimated costs have also been distributed between the City and County of Honolulu and Oceanic Properties, Inc. in order that the extent of public expenditures can be ascertained.

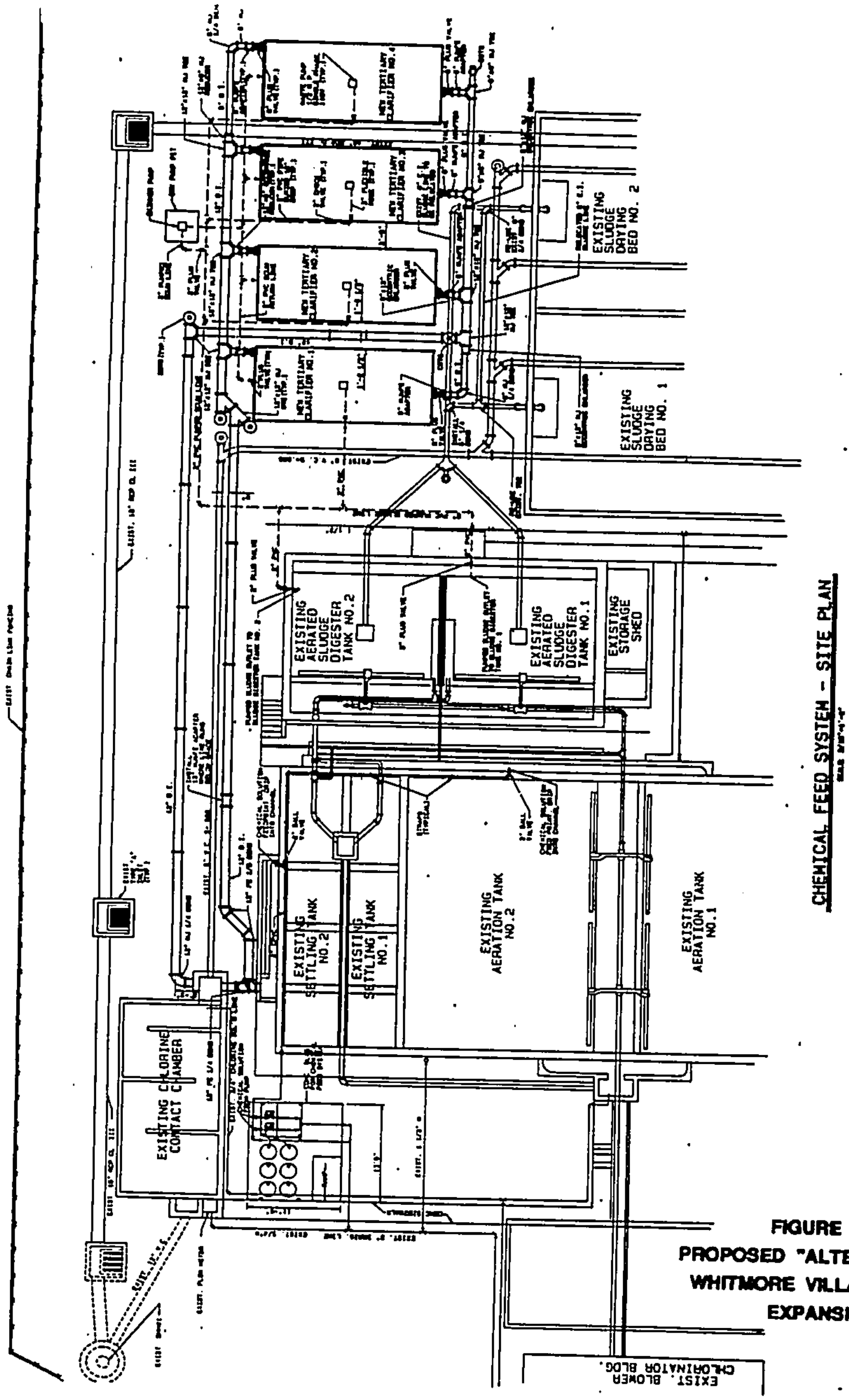

FIGURE 2-5
PROPOSED "ALTERNATIVE C"
WHITMORE VILLAGE WWTP
EXPANSION

TABLE 2-1

COMPARATIVE DEVELOPMENT COSTS
PROJECT ALTERNATIVES
WHITMORE VILLAGE WWTP MODIFICATIONS

Alternative	C&C Honolulu	Oceanic Properties	Total
A	-	N/A	$ 1,200,000
B	-	N/A	$ 1,200,000
C	$ 340,000	$ 350,000	$ 690,000

Source: Belt Collins & Associates, 1988; Kwock & Associates, Inc., 1988.

Project Alternatives A and B represent the most costly project alternatives as these proposed development options would, exclusive of design costs, require the expenditure of roughly $1.2 million. While no specific information is available, these project alternatives would primarily be borne by the City and County of Honolulu as Oceanic Properties would only pay for a portion of project design costs.

Implementation of Project Alternative C would cost just over half of Project Alternatives A and B.

However, in contrast to Alternatives A and B, a significantly greater proportion of the development costs for Project Alternative C would be borne by Oceanic Properties, the developer of Kahi-Kani subdivision.

Water Quality, Fish Habitat and Fisheries Management of the Wahiawa Reservoir

The lack of other feasible options, for the treatment and disposal of wastewater effluent from the Whitmore WWTP, results in the consideration of three project alternatives which would each continue to impact the Wahiawa Reservoir environment. However, considerable variation exists between the project alternatives in terms of their impacts upon water quality, fish habitat and fisheries management.

Project Alternatives A and B increase the volume of effluent discharge from the Wahiawa WWTP. Recent discussions with a representative of the State Division of Aquatic Resources indicate that the Wahiawa WWTP generates the greatest impact upon the Reservoir's water quality and fish habitat (Devick, 1989). The 1975 WRRC study concluded that the "....*Wahiawa STP discharge appears to have a noticeable impact on sediment nitrogen and phosphorus levels....*" from roughly 3,000 to 4,500 feet upstream and downstream of the Reservoir. In contrast, WRRC investigators concluded that the Whitmore WWTP had "*....an insignificant impact on nutrient levels...*" in sediments analyzed from the North Fork of Kaukonahua Stream.

Since Wahiawa WWTP effluent generates considerably more impact upon the water quality and fish habitat of Wahiawa Reservoir, as well as North and South Kaukonahua Streams, it can be concluded that additional effluent discharged via the Whitmore WWTP (Alternative C) would be less significant. Recent discussions with a State Division of Aquatic Resources representative (Devick, 1989) indicate that the additional volume of anticipated wastewater effluent from Whitmore Village, i.e., 0.051 mgd, would pose an insignificant impact upon the water quality and fish habitat of the Reservoir and both forks of Kaukonahua Stream. Consequently, the State's management of the fishery in the Reservoir would be least impacted by the implementation of Alternative C.

In contrast to Alternatives A and B, Alternative C is the only development option which incorporates an improved level of treatment within the Whitmore WWTP. As stated earlier, this recommendation was made by the Water Resources Research Center in its 1975 report concerning eutrophication and fish toxicity potentials in Wahiawa Reservoir.

Tertiary treatment was again recommended in a 1976 WRRC study of the eutrophic potential of Wahiawa Reservoir sediments. In its evaluation of management alternatives for the Reservoir, WRRC investigators concluded that:

"Tertiary treatment of the effluent may be nearly as efficient as diversion [of the effluent] as a means of reducing the nutrient load to the reservoir. Use of tertiary treatment followed by disposal into the reservoir would also provide a significant amount of H2O to the reservoir during low H2O periods" (Lum and Young, 1976).

In the context of overall report findings, this recommendation for tertiary treatment was made with particular reference to Wahiawa WWTP because of its primary contribution of nutrient loading to the Wahiawa Reservoir.

RECOMMENDED PROJECT ALTERNATIVE AND RELATED PROJECT DESCRIPTION

The evaluation of selected available information and the planning issues primarily influencing the project were the basis of project alternative selection. In summary, it is believed that these analyses dictate the implementation of project Alternative C. Anticipated project development costs for Alternative C are roughly half of the cost of implementing Alternatives A and B. However, the primary issue influencing this project is the impact of future wastewater flows upon the water quality, fish habitat, and fisheries management of the Wahiawa Reservoir.

From a water quality perspective, the diversion of wastewater effluent from the Reservoir to another treatment plant service area may represent the most desirable project option. However, this option is an impractical project alternative at this time that was discarded from further consideration. The significant cost of extending City and County of Honolulu force mains, installing lift stations, and other facilities that would be necessary to transport Whitmore Village flows to the Honouliuli WWTP in central Oahu presently eliminates this option as a realistic development option. However, as anticipated development continues in the central Oahu area, the economic feasibility of this option may materialize as the City and County of Honolulu may be able to share significant development costs with other private development organizations.

In the interim, Alternative C is not expected to generate any significant impact upon the water quality and fish habitat of the Reservoir and the Kaukonahua Streams because of the proposed use of an improved treatment system and the anticipated volume of wastewater flows from the Whitmore Village area. Further, the proposed Whitmore WWTP expansion to 211,000 gpd will still limit daily mass emissions to 50 pounds (23 kilograms) BOD (biochemical oxygen demand) and SS (total suspended solids). Proposed facility modifications at the plant will be capable of maintaining "28-28" BOD and SS concentrations as long as proposed facility changes are combined with City and County of Honolulu efforts to correct present operational deficiencies.

CHAPTER THREE
ENVIRONMENTAL SETTING

PROJECT LOCATION

Whitmore Village Wastewater Treatment Plant (Whitmore WWTP) is generally located on the Island of Oahu's Wahiawa area. Whitmore WWTP is accessible via Whitmore Avenue, situated on the north side of Wahiawa Town, and is less than one mile east of the Kamehameha Highway-Whitmore Avenue intersection. Whitmore WWTP and the adjacent Whitmore Village area are located along the north side of Kaukonahua Stream's North Fork (Figures 2-1 and 2-2).

SELECTED PHYSICAL CHARACTERISTICS

Soils

Soils in the Whitmore Village area are well-drained, moderately fine textured and fine textured soils that overlay basaltic lava flows. The U.S. Soil Conservation Service has categorized soils in the area as Wahiawa silty clay, Kolekole silty clay loam, Leilehua silty clay and Helemano silty clay (U.S. Soil Conservation Service, 1972).

Rainfall

The Whitmore Village area receives approximately 60 inches of rainfall on an annual basis (Department of Land and Natural Resources, Division of Water and Land Development, 1986).

Groundwater Characteristics

Ground water in the Whitmore Village and the adjacent Wahiawa Reservoir area is encountered approximately 300 feet above mean sea level (Wilson Okamoto & Associates, Inc., 1985). Since ground elevations in this area range from roughly 850 to 950 feet above sea level, the free water table and related artesian head is believed to be present roughly 550 to 650 feet below the surface waters of Kaukonahua Stream and the Wahiawa Reservoir. Consequently, surface Reservoir waters, which eventually percolate to the local ground water aquifer, are "filtered" through several hundred feet of basaltic substrata before recharge to the groundwater supply.

Hydrologic Balance of Wahiawa Reservoir

The Wahiawa Reservoir has a storage capacity of roughly three billion gallons at a spillway height of 80 feet. The Reservoir is supplied primarily by surface water originating from the Koolau Range which is eventually transported to the Reservoir via the North and South Forks of Kaukonahua Stream. Other sources of water supply to the Reservoir include direct rainfall, storm runoff, and wastewater effluent discharges from the Wahiawa and Whitmore wastewater treatment plants. Wastewater from the two treatment plants represents approximately four percent of the total annual input. Water outputs from the Reservoir include the use of Reservoir waters by Waialua Sugar Company for the irrigation of nearby sugarcane fields; spillway overflow during intensive inflow conditions; evaporation; reservoir leakage; and percolation (Young et al, 1975).

In its 1975 study of the Reservoir, WRRC investigators calculated the annual water balance of the Reservoir using streamflow data from the 1953-1968 period and other statistical assumptions concerning rates of evaporation, percolation, and other factors. In summary, it was estimated that approximately 15.2 mgd of water inputs to the Reservoir each year while roughly 14.5 mgd of water is output from the Reservoir. Given the three billion gallon storage capacity of the Reservoir, the water volume of the Reservoir is exchanged, at least, five times each year.

Other WRRC hydrologic analyses of the Reservoir water balance indicated, in part, the following additional conclusions:

1. The North Fork of Kaukonahua Stream has a higher streamflow than the South Fork;
2. Streamflow is greatest during the months of March and November and lowest during the months of June and September;
3. The water volume of the Reservoir is highest in April and reaches its lowest level in October;
4. Water output exceeds input during the month of June and from August to late October;
5. Maximum rainfall occurs during the months of December through January; precipitation is the least during the months of May to October;
6. The highest level of irrigation use occurs when rainfall occurs at its minimum levels; irrigation drawdown is lowest during December; and
7. "***Leakage loss is higher when the Reservoir has a larger volume of water and lower during low water levels***" (Young et al, 1975).

SELECTED BIOLOGICAL AND CHEMICAL CHARACTERISTICS

In their study of **The Eutrophic Potential of Wahiawa Reservoir Sediments** in 1976, WRRC investigators Lum and Young concluded, in part, that nitrogen, phosphorus, and chemical oxygen levels in the Wahiawa Reservoir were "*...sustained and increased as a result of contact with sediments under anaerobic conditions*". Further, these investigators also observed that "*nutrients from sediments supported eutrophic levels of algal growth*".

As stated in Chapter Two, the ultimate concern of State aquatic resource biologists regarding the nutrient loading of the Reservoir is phytoplankton production.

"*During the warmer periods of the year, the normal green coloration of the water intensifies dramatically near the Wahiawa Sewage Treatment Plant outfall. The increased phytoplankton production produces a net excess of oxygen, most of which is lost to the air, and the huge fish population*" (Paty, 1989).

Significant variations in dissolved oxygen (DO) generate an imbalance in the fish population of the Reservoir. This imbalance, in turn, creates a management problem for the State Division of Aquatic Resources.

It should be noted, however, that the variation in DO levels and the related imbalance of the fish population involves other environmental factors such as the drawdown of reservoir waters for irrigation purposes. The nutrient loading of the Reservoir via wastewater effluent, urban runoff and other sources is compatible with the primary use of the Reservoir waters for irrigation purposes.

LAND USES

Whitmore Village

Whitmore Village was originally developed to serve as a residential community for sugarcane production workers in Central Oahu. Despite the reduction in Central Oahu's sugarcane and pineapple production in the mid-1970's, Whitmore Village continues to serve as a residential community for retired plantation workers, as well as for younger residents employed at nearby military installations, commercial activities in Wahiawa, and the more prominent and distant commercial center of Honolulu.

Whitmore Village has a resident population of approximately 3,350 persons. This population is expected to grow to approximately 4,200 persons following the completion of Phases II, III and IV of Kahi-Kani Subdivision in late 1990. Beyond 1990, the residential population is expected to remain generally stable since all developable residential lots in the Whitmore Village area will have already been developed. However, City and County of Honolulu officials indicate that present County zoning permits the construction of 50 additional "Ohana" housing units on existing houselots. Such development would generate an additional residential population of roughly 200 persons or less if approved by the City and County of Honolulu.

CORRECTION

THE PRECEDING DOCUMENT(S) HAS
BEEN REPHOTOGRAPHED TO ASSURE
LEGIBILITY
SEE FRAME(S)
IMMEDIATELY FOLLOWING

SELECTED BIOLOGICAL AND CHEMICAL CHARACTERISTICS

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However, as indicated in Chapter Two, the City and County of Honolulu, Division of Wastewater Management, could deny sewer connection rights to these Ohana residential units on the basis of an inadequate wastewater treatment capacity.

Wahiawa Reservoir

Wahiawa Reservoir was constructed as an irrigation storage facility in 1906 to support the production of sugarcane. The Reservoir is presently owned by Castle and Cooke, Inc. and is being leased to Waialua Agricultural Company which continues to use the Reservoir for this purpose.

A second use of the Reservoir was introduced in 1928 with the discharge of wastewater effluent, from the Wahiawa WWTP, into the South Fork of Kaukonahua Stream. Later, in 1970, the discharge of effluent from the secondary wastewater treatment facility at Whitmore Village added additional wastewater flow to the North Fork of Kaukonahua Stream. While providing receiving waters for both treatment facilities, nutrient-enriched waters also provided an inexpensive nutrient supplement for Waialua Sugar Company's irrigation water supply.

Recreational fishing was established as the Reservoir's third use in 1957 when the Reservoir was stocked by the State Division of Fish and Game with various fresh-water fish and used as a local sport fishery. The fishery is currently managed by the State Department of Land and Natural Resources, Division of Aquatic Resources. The Wahiawa Public Fishing Area contains approximately 300 acres of fishable water. Fish available within the Reservoir include bluegill sunfish, tilapia, large mouth bass, smallmouth bass, tucunare, channel catfish, Chinese catfish, snakehead, carp, and oscar (State Division of Aquatic Resources, 1981).

Surrounding Land Uses

A communications station, operated by the U.S. Navy, is located along Whitmore Avenue. However, surrounding properties primarily include lands, owned by Castle and Cooke, Inc., that are currently used by Dole Pineapple Company for pineapple production. Representatives of Oceanic Properties, Inc., a subsidiary of Castle and Cooke, Inc., indicate that present pineapple production on these lands continues to be profitable (Kim, 1989). However, land values in Central Oahu, and the anticipated demand for residential homes on Oahu, are expected to eventually result in expanded residential and commercial development on these agricultural lands. The caveat to future development of these agricultural lands will be the availability of required infrastructure, e.g., roads, electrical power, and wastewater collection, treatment and disposal facilities.

The potential impact of future residential development upon wastewater system requirements will be the greater population to be served. For wastewater planning purposes, the City Division of Wastewater Management conservatively assumes that each household will contain four persons and that per capita wastewater generation will be approximately 60 gallons per day.

WHITMORE VILLAGE WASTEWATER SYSTEM

General

The Whitmore Village wastewater system includes an existing collection system (Figure 3-1) and an extended aeration process (Figure 3-2).

Present and Future Wastewater Generation from the Whitmore Village Area

An estimated resident population of 3,352 persons (Ng, 1989) currently generates an average wastewater flow of approximately 0.16 mgd to Whitmore WWTP, or approximately 48 gallons per capita per day. This estimate is based upon the presence of 838 homes in the Whitmore Village area (including Phase I of the Kahi-Kani Subdivision), an assumed household size of four persons per household, and plant influent records for the past three years.

The anticipated wastewater flows from the soon-to-be-completed Kahi-Kani Subdivision project will increase wastewater flows in the Whitmore Village area. As stated in Chapter Two, Phases II, III and IV of this project will connect an additional 214 single family housing units to the Whitmore Village sewage collection system. Assuming a household size of four persons and a per capita waste generation rate of 60 gallons per day, the future population of Phases II, III, and IV is expected to generate an additional 0.052 mgd of wastewater flow to Whitmore WWTP by the end of 1990.

Representatives of the City Division of Wastewater Management indicate that existing City zoning could permit the development of 50 additional "Ohana" housing units in the Whitmore Village area. However, it is expected that "Ohana" applications would be denied by the City and County of Honolulu in the absence of greater treatment capacity.

During, at least, the 1990-1995 period, it is believed that average wastewater flows in Whitmore WWTP will not exceed 0.252 mgd. This volume is not expected to increase unless surrounding lands, presently in pineapple production, are approved and developed for residential and/or other land uses. However, such development would require significant land use approvals by the State Land Use Commission, the City and County Planning Commission and the City Council. Further, such development could not occur without the availability of adequate treatment capacity and an effluent disposal plan that would need to be accepted by the City Division of Wastewater Management, the State Department of Health, and the State Division of Aquatic Resources.

Collection System

The existing collection system serving the Whitmore Village area consists of eight-inch mains which are located along secondary street easements in the area. The soon to-be completed Kahi-Kani subdivision development includes the installation of additional eight-inch sewer lines which have been integrated with the initial collection system.

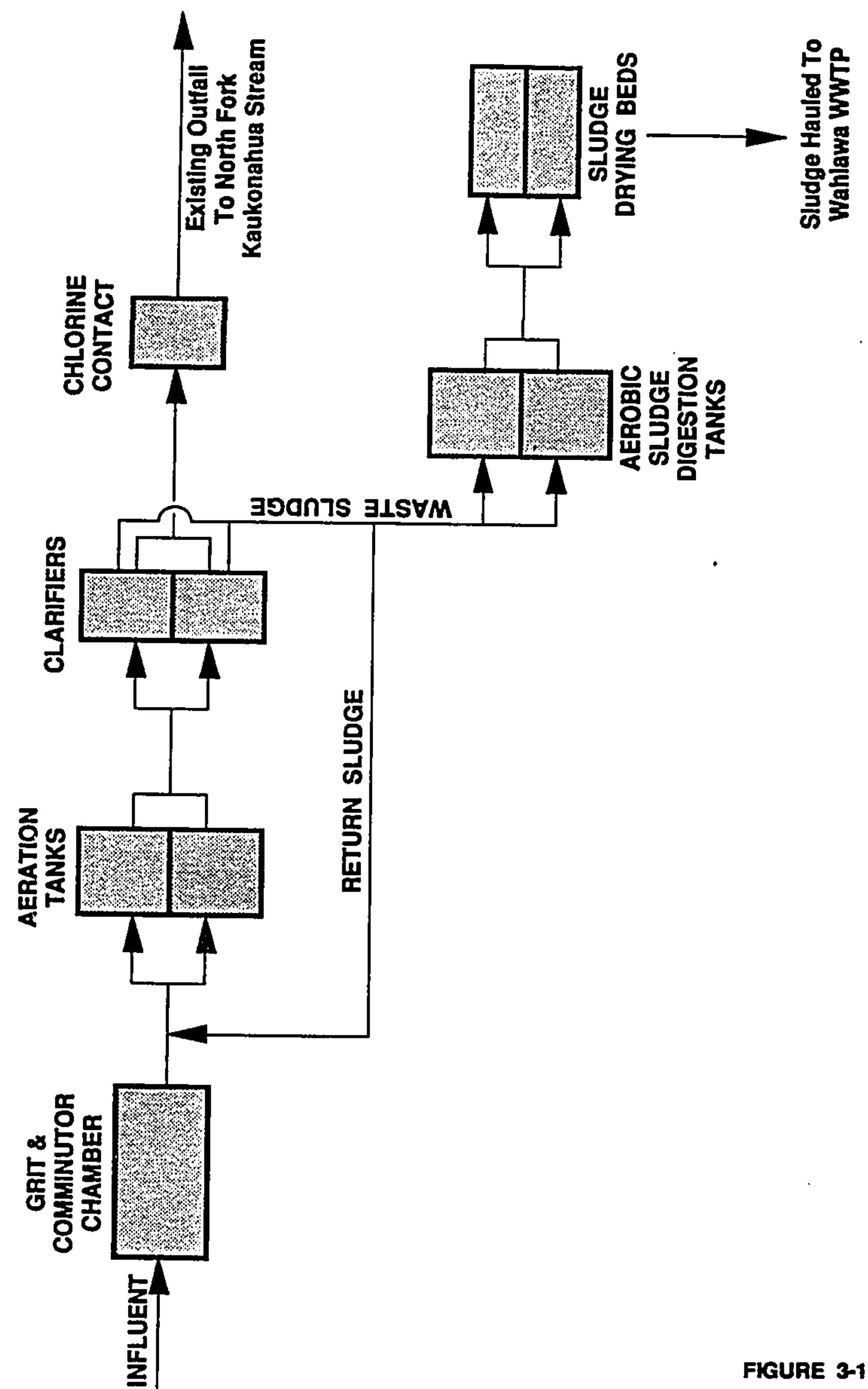

FIGURE 3-1
SCHEMATIC FLOW DIAGRAM
WHITMORE VILLAGE WWTP

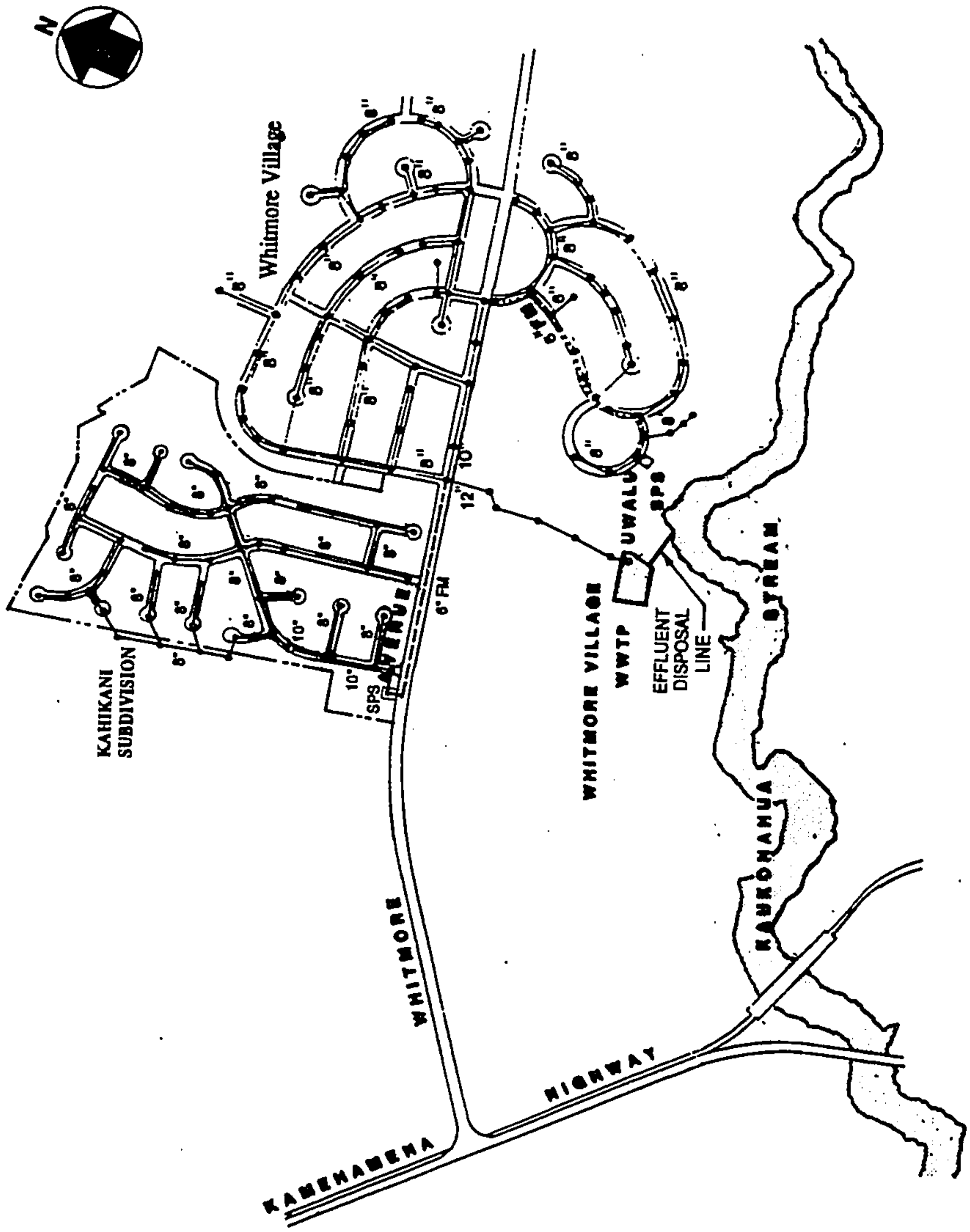

FIGURE 3-2
EXISTING COLLECTION SYSTEM
SERVING WHITMORE VILLAGE

Treatment and Disposal

The existing extended aeration process is capable of handling 0.2 mgd of influent flow which has a five-day BOD and SS concentrations of 200 milligrams per liter (mg/l).

"*Raw influent passes through the grit and comminutor chamber and combines with return sludge before entering the aeration tanks. There are two aeration tanks, each measuring 27 by 36 feet, with 13.75 feet sidewater depth. After the sewage is aerobically stabilized by microorganisms in the tanks, it flows into settling tanks. The two settling tanks are rectangular, each measuring 6 feet by 36 feet, with 10 feet sidewater depth. A portion of the settled solids is recycled to the aeration tanks to maintain desired concentration of mixed-liquor suspended solids, and a portion is wasted*" (Wilson Okamoto & Associates, 1985).

A 1987 review of Whitmore Village WWTP operations and maintenance activities by ES Environmental Services, Inc. indicates that present mixed-liquor suspended solids concentrations range from 1,200 to 1,400 mg/l. However, comparable data from earlier years indicate more desirable levels of 800 to 900 mg/l (ES Environmental Services, Inc., 1987; Wilson Okamoto & Associates, 1985).

Clarified effluent is further treated via a chlorine contact chamber. Treated effluent is ultimately discharged into the North Fork of Kaukonahua Stream via a 12-inch pipe and 30-inch storm drain.

The solid stream of Whitmore WWTP includes two aerobic sludge digesters and sludge drying beds. However, one of the two aeration tanks has been converted to a sludge storage tank. Operations personnel have experienced difficulty in decanting the digester effectively at lower solids concentrations. Dissolved oxygen (DO) concentrations in both the aerobic digester and the sludge storage tank have been observed by ES Environmental Services to be less than one mg/l. DO concentrations between one and two parts per million are normally desired for effective sludge stabilization (Reid, 1989; ES Environmental Services, 1987).

Existing sludge drying beds are not in use because of the higher rainfall that occurs in the Whitmore Village area. Present operational procedures include the weekly transport of aerobically-digested sludge to nearby Wahiawa WWTP where the sludge is combined with the influent flows (Wilson Okamoto & Associates, Inc., 1985).

SELECTED STATUTES AND REGULATIONS AFFECTING WHITMORE WWTP OPERATIONS AND POTENTIAL FACILITY MODIFICATIONS

NPDES Permit

The City and County of Honolulu is authorized to discharge secondary-treated wastewater effluent via its current National Pollutant Discharge Elimination System (NPDES) permit. This permit, which expires on March 1, 1992, was issued by the State Department of Health in compliance with the provisions of the federal Clean Water Act. This federal statute requires, in part, that States establish effluent limitations and monitoring requirements for all wastewater treatment plants.

The existing NPDES permit for the Whitmore WWTP operation establishes effluent discharge standards for BOD, SS, fecal Coliform bacteria, and pH (Table 3-1).

The NPDES permit also provides the following general criteria concerning the quality of receiving waters:

"*The discharge from the Whitmore Village Sewage Treatment Plant shall not interfere with the attainment of maintenance of that water quality which assures protection of public water supplies and the protection and propagation of a balanced indigenous population of shellfish, fish, and wildlife, and allows recreational activities in and on the water*" (State Department of Health, 1988).

TABLE 3-1

EFFLUENT DISCHARGE LIMITATIONS
NPDES PERMIT
WHITMORE VILLAGE WWTP

	DISCHARGE LIMITATIONS			
Effluent Characteristic	Monthly Average (lbs/day)	Weekly Average (lbs/day)	Oth.Units Monthly Average	Specify Weekly Average
Biochemical Oxygen Demand (5 day)	50	75	30 mg/L	45 mg/L
Suspended Solids	50	75	30 mg/L	45 mg/L
Fecal Coliform Bacteria	N/A	N/A	200/100ml	N/A
pH	Not less than 6.0 standard units nor greater than 9.0 standard units.			

Source: State of Hawaii, Department of Health, 1988.

Other Clean Water Act Provisions

A portion of the federal Clean Water Act (40 CFR 131.12) concerns "antidegradation requirements" for both point and non-point sources of pollution. The intention of this provision of this provision is to make States establish more definitive procedures for controlling non-point sources of pollution. In 1987, the U.S. Environmental Protection Agency (EPA) provided guidelines to its Region IX states (including the State of Hawaii) for the implementation of the Clean Water Act antidegradation provisions. The EPA guidelines indicate that four basic elements should be incorporated into the State's implementation procedures:

Task A - Identify actions that require detailed water quality and economic impact analyses.

Task B - Determine that lower water quality will fully protect designated uses.

Task C - Determine that lower water quality is necessary to accommodate important economic or social development in the area in which the waters are located.

Task D - Complete intergovernmental coordination and public participation.

If a given Task A analysis determines that a proposed project will not lower water quality, no further analyses are needed and EPA considers 40 CFR 131.12 to be satisfied (U.S. Environmental Protection Agency, 1987).

Chapter 62, Administrative Rules, State Department of Health

Chapter 62 of the State Administrative Rules governs the development and operation of private and public wastewater collection and treatment facilities. Selected portions of the statute, e.g., treatment unit requirements, which are relevant to the operation and the design of any potential expansion of private wastewater treatment facilities, may also be applicable to Whitmore WWTP. Otherwise, the design of all County wastewater treatment facilities will be based on County standards, or the 1978 edition of the Recommended Standards for Sewage Works, commonly known as the "Ten States' Standards".

The treatment unit requirements for private wastewater treatment facilities indicate that the design will include provisions for, at least, the following:

1. sludge digesters, or aerated sludge holding tanks, to treat and store at least the amount of sludge generated over a 30-day period;

2. continuous disinfection of the treated effluent;

3. aeration tank loading that does not exceed 12.5 pounds of BOD5 per 1,000 cubic feet;

4. for treatment systems using final settling tanks, the detention time will not be less than four hours and the surface overflow rate will not exceed 300 gpd per square foot;

5. consideration of flow equalization to assure continuous compliance with State effluent requirements;

6. easy access for operators to permit necessary operation, maintenance and repair activities (State Department of Health, 1988).

Since the Whitmore Village WWTP is a public wastewater treatment facility, the director of the State Department of Health may waive any of the preceding requirements.

STATE AND COUNTY LAND USE DESIGNATIONS

The Whitmore WWTP is situated within a State agricultural district. Permitted uses within the State agricultural district include, in part, the development and operation of public utility systems.

Development plan designations of the City and County of Honolulu, Department of Land Utilization, indicate that Whitmore WWTP is also located within an area which the City has identified for future agricultural activities (Figure 3-3).

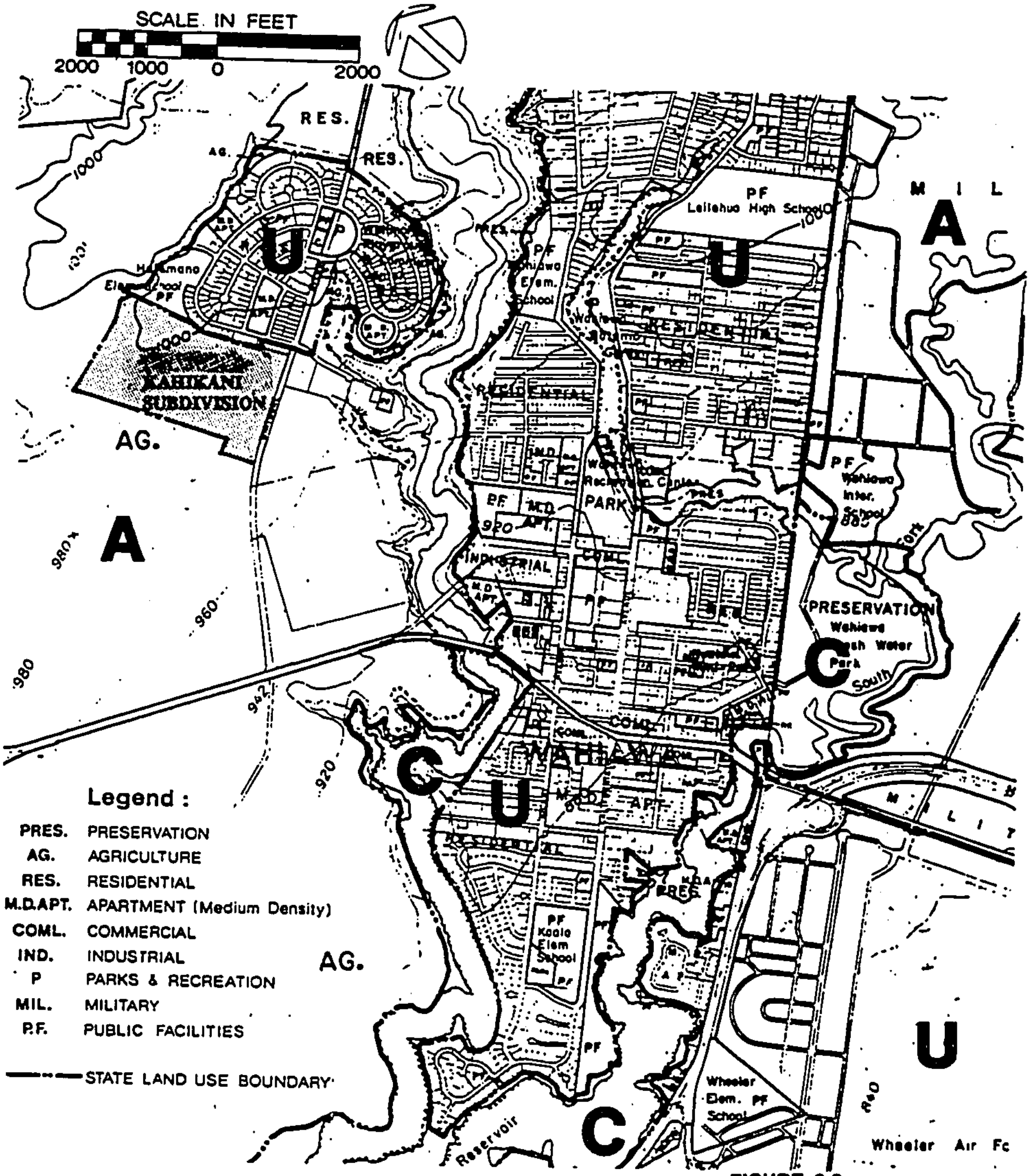

FIGURE 3-3
CITY & COUNTY OF HONOLULU
DEVELOPMENT PLAN DESIGNATION
WHITMORE VILLAGE AREA

CHAPTER FOUR
SIGNIFICANT ENVIRONMENTAL CONSEQUENCES AND PROPOSED MITIGATIVE MEASURES

INCREASED WASTEWATER FLOWS TO THE WHITMORE WWTP

Effluent Quality

The increase in wastewater influent from an average flow of 0.160 to 0.211 gpd will decrease the concentration of Whitmore WWTP's mass emissions, i.e. BOD and SS, unless the increased flow is combined with plant modifications and improvements in plant operations.

The installation of four new clarifiers, the use of polymer in the treatment system, and other operational procedural changes in plant operations are expected to reduce the concentration of mass emissions from "30-30" BOD and SS to 28 BOD and 28 SS. Appendix A provides more detailed calculations of existing and anticipated mass emissions of BOD and SS that were prepared by Belt Collins & Associates, Inc.

The expected reduction in the concentration of mass emissions will result from plant modifications that will increase the removal of solids during the treatment process. The concentration of the pollutants will be reduced to a point which will be equal, or less than, the mass emission rate allowed by the plant's existing NPDES permit.

Clarifiers primarily remove solid material through settling. Expanded clarifier capacity will be added to the plant to maintain a five-hour detention time during average daily flows. The added detention time will provide an increased amount of time for sludge settleability.

Plant operations will also be modified to incorporate the addition of polymers after the plant's clarification basin. This operational activity is also expected to increase the settleability of the sludge.

"*...Polymer gathers in loose particles in suspension and begins to settle under the combined weight of the attached particles. The interaction between the suspended solids and the added polymer will result in greater removal rates of suspended solids. The higher settling rate allows the plant to treat a greater amount of wastewater...*" (Belt Collins & Associates, Inc., 1988).

It is also recommended that additional modifications in plant operational procedures be implemented to ensure a consistent increase in the quality of mass emissions from Whitmore WWTP. Recommended operational procedures include the following:

1. Observations by ES Environmental Services in 1987 indicate that DO levels in the aeration tanks and aerobic digesters are too low (less than one part per million). The maintenance of DO levels between one and two parts per million is recommended (Reid, 1989; ES Environmental Services, 1987).

2. Past microscopic examinations of the sludge in the aeration tank, by ES Environmental Services, Inc., observed heavier growths of filamentous bacteria. In the short term, the bacteria can be controlled by systematic does of one to 10 ppm of chlorine. Long-term control, however, requires the maintenance of proper DO levels, i.e., one to two ppm, in the system (Reid, 1989).

In summary, anticipated mass emission concentrations from Whitmore WWTP will be the same, or less, even though the volume of effluent discharge increases. The City's implementation of more effective removal techniques will proportionally reduce concentrations of both nutrients and suspended solids.

Treatment Plant Capacity

The proposed modifications to the Whitmore WWTP facilities and operations would increase the treatment plant capacity of Whitmore WWTP to 0.211 mgd. However, increased capacity would not encourage further development of the Whitmore Village area since the additional flows generated by Phases II, III and IV of the Kahi-Kani Subdivision project would absorb all of the capacity available from the modified plant facility.

Water Quality and Fish Habitat of Wahiawa Reservoir

Increased wastewater flow through the plant will also increase the volume of effluent discharge to the North Fork of Kaukonahua Stream. However, the volume of increased effluent discharges from Whitmore WWTP will pose an insignificant impact upon the water quality and fish habitat of the Wahiawa Reservoir (Devick, 1989).

Reduced concentrations of nutrient and suspended solids from the effluent will maintain or reduce the existing amount of sediments that deposit in the surface waters and bottom of Wahiawa Reservoir. Consequently, additional effluent is not expected to contribute significantly to the eutrophication of the Reservoir.

The anticipated impact of the added effluent is also supported by a variety of environmental factors characterizing Kaukonahua Stream and the Reservoir environment.

1. Water Resource Research Center (WRRC) investigators concluded in 1975 that Whitmore WWTP has *"an insignificant impact on nutrient levels...."* in sediments analyzed from the North Fork of Kaukonahua Stream.

2. The North Fork of the Kaukonahua Stream has a considerably higher streamflow input than the South Fork of the Stream. WRRC scientists concluded in 1975 that an annual streamflow input of 8,547 million gallons to the North Fork of Kaukonahua Stream versus 5,094 million gallons for the South Fork. Consequently, a considerably greater dilution of nutrients and suspended solids is occurring in the North Fork of the Stream.

3. Turbidity is considerably less in the North Fork due to greater dilution and less phytoplankton (Devick, 1989).

4. A significant fish population accumulates near the Whitmore WWTP outfall primarily due to availability of nutrients and adequate oxygen levels.

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APPENDIX A

DETAILED CALCULATIONS
EXISTING AND ANTICIPATED CONCENTRATIONS
OF BOD AND SS
WHITMORE VILLAGE WWTP

Prepared by

Belt Collins & Associates
Honolulu, Hawaii

DETAILED CALCULATIONS - EXISTING AND ANTICIPATED CONCENTRATIONS OF BOD & SS WHITMORE VILLAGE WWTP

Background to Calculations:

The Whitmore Village Wastewater Treatment Plant (WWTP) is presently operated by the City and County of Honolulu, Division of Wastewater Management (DWWM), at an average flow of 0.16 million gallons per day (MGD). This flow is less than the plant's original design capacity of 0.20 MGD. The plant was originally designed to operate as an extended aeration process, but was later found to operate more efficiently in a "quasi-extended aeration/conventional aeration" mode. It features a grit chamber and comminutor at the headworks, aeration tanks (with a 31-hour detention period at average daily flow), clarifiers, a chlorine contact tank, and an outfall at the North Fork of Kaukonahua Stream. Aerobic digesters are used to further stabilize and store the excess sewage sludge, which is eventually removed and transported via tanker truck to Wahiawa and Honouliuli WWTP's for ultimate disposal. Existing sludge drying beds are not utilized due to the area's high rainfall.

Phases II, III, and IV of the Kahi-Kani subdivision project will result in the connection of 214 additional housing units to the Whitmore Village collection system. For design purposes, it can be assumed that each new unit will contain four persons, and that each person will generate 60 gallons per day (the latter figure is conservative when compared to the 48 gallons per capita per day [gpcd] produced by the existing population of 3,352 persons). The new development will therefore result in a design average flow of 0.211 MGD. The higher, weekend flows that will result can be estimated by assuming that the existing population would also generate 60 gpcd; this would result in a design "weekend" flow level of 0.252 MGD.

To accomodate these increased flows, DWWM, in conjunction with Belt Collins & Associates (BCA), has developed plans to expand the treatment capacity of Whitmore Village WWTP. The upgrade will involve the addition of a chemical feed system (currently under construction) and four tertiary clarifiers. Sludge from the process would be pumped to the existing aerobic digesters. To assist in the upgrading of the treatment plant's capacity, DWWM plans to provide further aeration capacity through the installation of additional blowers for the existing aeration units and the installation of fine air diffusers. A portion of the air currently supplied to the aerobic digesters will also be diverted to the aeration tanks to supplement their air supply. To compensate for the resultant loss in aeration capacity, one 7.5-HP floating aerator will be installed in each of the digesters.

The upgrade is designed to produce effluent that will not exceed National Pollutant Discharge Elimination System (NPDES) permit limitations for Biochemical Oxygen Demand (BOD) and Suspended Solids (SS), as currently set for Whitmore Village WWTP. The treatment plant presently is allowed to discharge effluent with concentrations of 30 mgl for both BOD and SS. This is roughly equivalent to mass emission rates (MER's) of 23 kilograms per day for both parameters.

DESIGN FLOW CALCULATIONS

Whitmore Village WWTP is presently operated at an average daily flow of approximately 0.16 MGD. For the estimated resident population of 3,352 persons (Ng, 1989), this is equivalent to a wastewater flow generation of 48 gpcd.

Phases II, III, and IV of the Kahi-Kani subdivision are expected to result in the eventual connection of 214 additional housing units to the Whitmore Village sewer system. In order to estimate the resultant contribution of these new units, an occupancy rate of 4 persons per unit will be used to project the future increase in population.

Calculations to evaluate BOD and SS effluent levels were based on average flow. The average design flow used in these calculations was derived as follows:

$Q_{(ave.-exist.)}$ = 0.16 MGD

$Q_{(additional)}$ = (214 units) x (4 persons/unit) x (60 gal/capita/day)
= 0.051 MGD

(The value of 60 gpcd used above is conservative in the sense that it exceeds the estimated actual rate of 48 gpcd.)

$Q_{(ave.-new)}$ = $Q_{(ave.-exist.)}$ + $Q_{(additional)}$
= 0.16 MGD + 0.051 MGD
= 0.211 MGD

The future population can reasonably be expected to generate flows comparable in magnitude to the existing average per capita flow of 48 gpd. A design per capita flow of 60 gpd can therefore be applied to the entire population to predict future "weekend" flow conditions:

$Q_{(wkend.)}$ = [(3,352 persons) + (214 units)(4 persons/unit)] x 60 gal/capita/day
= 0.252 MGD

MASS EMISSION RATES CALCULATIONS

Per NPDES permit requirements, the effluent presently being discharged from Whitmore Village WWTP may have maximum BOD and SS concentrations of 30 mg/l. The mass emission rates (MER's) allowed by the permit (based on an NPDES design flow of 0.20 MGD, which was the plant's original design capacity) can therefore be calculated as follows:

Max. Allow. MER (BOD) = (NPDES Design Flow) x (Max. BOD Concentration)

= (0.20 MGD) x (30 mg/l)

= 22.71 kg/d BOD

Similarly, for SS,

Exist. MER (SS) = 22.71 kg/d SS

The plant modifications are being made to accomodate the expected increase in wastewater flow contributions from the additional development. Using a value of 60 gpcd, the average daily flow would therefore increase to 0.211 MGD. In order to meet the NPDES permit requirements for the MER's of BOD and SS, the required effluent concentrations can be found via a mass-balance computation. Assuming that the nature of the current sewage flows will be characteristic of the future sewage contributions:

$$\text{Req'd. BOD Conc.} = \frac{\text{Exist. MER (BOD)}}{\text{Future Ave. Flow}}$$

$$= \frac{\text{22.71 kg/d (BOD)}}{\text{0.211 MGD}}$$

= 28 mg/l

Similarly for SS,

Req'd. SS Conc. = 28 mg/l

EFFLUENT BOD & SS CALCULATIONS

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Background: (after Metcalf and Eddy, Inc., 1979)

In the design and control of the activated sludge process, the two most commonly used parameters are (1) the food-to-microorganism ratio (F/M), and (2) the mean cell residence time (θ_c).

The food-to-microorganism ratio is defined as,

$$F/M = \frac{S_0}{\theta_h X} \tag{1}$$

where
- F/M = food-to-microorganism ratio, d^{-1}
- S_0 = influent BOD concentration, mg/l
- θ_h = hydraulic detention time of the aeration tank, d = V/Q
- V = aeration tank volume, ft^3
- Q = influent wastewater flowrate, ft^3/d
- X = concentration of mixed liquor volatile suspended solids (MLVSS), mg/l

The specific utilization rate, U, is related to the food-to-microorganism ratio by,

$$U = \frac{(F/M)E}{100} \qquad (2)$$

where E = process efficiency, %.

Substituting Eq. (1) for the food-to-microorganism ratio and $[(S_0 - S)/S_0]/100$ for the efficiency (where S = effluent BOD concentration, mg/l) yields,

$$U = \frac{S_0 - S}{\theta_h X} \qquad (3)$$

The mean cell residence time is related to the food-to-microorganism ratio by,

$$\frac{1}{\theta_c} = YU - k_d \qquad (4)$$

where
θ_c = mean cell residence time, d
Y = maximum yield coefficient (i.e., the ratio of the mass of cells formed to the mass of substrate consumed)
U = specific utilization rate, d^{-1}
k_d = endogenous decay coefficient (i.e., the ratio of the mass of cells decayed per day to the mass of cells in the aeration tank), d^{-1}

Problem:

Determine the effluent BOD and SS concentrations that will be achieved using the planned chemical feed system and tertiary clarifiers, together with the proposed improvements to the aeration system.

Calculations:

Given: $\theta_c = 8$ d

A mean cell residence time of 8 days was chosen for analysis based on the 7.5-day MCRT actually employed in current plant operations (refer to Exhibit I). It is conservative in the sense that it is higher than the value of 7.5 days predicted by computer simulations (as performed by ES Environmental Services, Inc. [1987] -- refer to Exhibit II) for roughly the same flow magnitude (0.21 MGD vs. the 0.211 MGD design average flow); a lower mean cell residence time will result in a lower (calculated) effluent BOD level.

Exhibit I

(Toma, 1989)

DATE: 12-21-88 ANALYTICAL RESULTS PWSIM35

LOCATION: WHITMORE VILLAGE CHEMIST: K. NISHIMURA

DISCRETE SAMPLE EFFLUENT

TOTAL COLIFORM	FECAL COLIFORM	SETTLEABLE SOLIDS	EFFLUENT PH	RESIDUAL CHLORINE
	<0.0001		6.7	7.5

FLOATABLES	ODOR	GREASE
NONE	NONE	

COMPOSITE SAMPLE

	BOD	SS	TOTAL P	KJEL N	TOTAL N
INFLUENT (MG/L)	215	160			
MER (KG/DAY)	131.10	97.56	*******	*******	*******
EFFLUENT (MG/L)	7	20	3.9		
MER (KG/DAY)	4.27	12.20	2.38	*******	*******
REMOVAL (%)	96.74	37.50	*******	*******	*******

TOTAL FLOW 0.1611 MGD
OTHER PARAMETERS
VIOLATIONS
REMARKS
RETYPE DATE AND/OR HIT ENTER
BMYJOB

RECEIVED
NOV 16 1989
P 70
BELT, COLLINS & ASSOCIATES

C: Greg. Hayashi
Belt Collins,
521-5361

Whitmore Village WWTP
Marvin Toma - plant Superv
Ph - 621 7747

Recir Rate: 100% @ 200,000 gal/day
MCRT: 7.5 days
Waste gal: 12,600 gals.
underdrain Conc. (return): 2000 mg/l
MLSS = 1000 mg/l
Aeration tank volume: 102,060 gals.
final Clarifier Volume: 9315 gals.

JV
LA
PPW
EI
KN
CK
BC
EM
RI
LL
AY
AC
CP
HC

Exhibit II

(ES Environmental Services, Inc., 1987)

WHITMORE VILLAGE

DATE: 06-15-1987
TIME: 19:12
BOD: 250
TSS: 225
TEMP 27

BIOLOGICAL REACTOR PERFORMANCE, PAGE 1

FLOW MGD	MAX MLSS	MLVSS %	F/M	MCRT DAYS	SVI	RAS MGD	RAS MG/L	WAS LBS/DAY
0.09	860	58	0.18	16.1	100	0.01	10000	81
0.10	847	59	0.20	15.2	100	0.01	10000	91
0.11	835	60	0.22	14.0	100	0.01	10000	101
0.12	825	61	0.23	12.6	100	0.01	10000	111
0.13	816	61	0.25	11.4	100	0.01	10000	122
0.13	996	60	0.22	13.3	100	0.01	10000	127
0.14	986	61	0.24	12.2	100	0.02	10000	138
0.15	977	61	0.25	11.2	100	0.02	10000	148
0.16	970	62	0.27	10.3	100	0.02	10000	159
0.17	962	62	0.28	9.6	105	0.02	9542	170
0.18	956	63	0.30	9.0	113	0.02	8823	181
0.19	950	63	0.31	8.4	121	0.02	8233	192
0.20	945	63	0.33	7.9	129	0.03	7741	203
0.21	940	64	0.34	7.5	136	0.03	7326	214
0.22	935	64	0.36	7.0	143	0.03	6972	225
0.22	931	64	0.37	6.7	150	0.04	6667	237
0.23	927	65	0.39	6.4	156	0.04	6402	248
0.24	924	65	0.40	6.0	162	0.04	6169	259
0.25	920	65	0.42	5.8	165	0.05	5964	271
0.26	917	65	0.43	5.5	173	0.05	5782	282

The use of a low MCRT here is also appropriate since treatment plants in Hawaii typically need to run "thinner" (i.e., with relatively lower MCRT's) than similar plants in the Continental U.S. This is because the greater sludge age corresponding to the higher MCRT's, combined with the warm temperatures, act to promote the growth of undesirable, filamentous microbial growth.

Assume: $Y = 0.7$
$k_d = 0.05\ d^{-1}$

According to Metcalf & Eddy, Inc. (1979), Y values (@ 20°C) commonly range from 0.6 to 0.8, with a "typical" value of 0.6. In Hawaii, however, the warmer temperatures which are present would tend to result in a relatively higher value for Y; therefore, a value of Y = 0.7 will be used for this analysis.

Similarly, Metcalf & Eddy, Inc. (1979) state that values for k_d (@ 20°C) commonly range from 0.04 to 0.075 d^{-1}, with a "typical" value of 0.06. In this case, the presence of warmer temperatures would indicate that a lower k_d value might be expected, hence the value of 0.05 d^{-1} will be used.

The specific utilization rate is found using Eq. (4):

$$\frac{1}{9} = (0.7)U - 0.05$$

$$U = 0.2500\ d^{-1}$$

The detention time is determined as follows:

Volume of aeration tanks = 27,216 ft^3

Q = 0.211 MGD

$$\theta_h = V/Q$$
$$= [(27{,}216\ ft^3)(7.48\ gal/ft^3)]/(211{,}000\ gal/d)$$
$$= 0.96\ d\ (= 23.2\ hr)$$

Then, based on treatment plant data for the period from 4/5/88 to 10/19/89 (Toma, 1989),

S_0 = 224 mg/l BOD (calulated average of BOD grab-sample data)
X = 800 mg/l MLVSS (using an actual MLSS value of 1,000 mg/l [refer to Exhibit I]), it is assumed that MLVSS is approximately 80% of MLSS)

The BOD concentration of the influent into the tertiary clarifiers can be calculated by substituting the above values into Eq. (3),

$$0.2500 = \frac{224 - S}{(0.96)(800)}$$

S = 31.04 mg/l BOD (secondary effluent, i.e., influent to tertiary clarifier)

The BOD removal efficiency can therefore be calculated as:

$$E_{BOD} = \frac{BOD_{infl.} - BOD_{effl.}}{BOD_{infl.}} \times 100\% \qquad (5)$$

$$= \frac{S_0 - S}{S_0} \times 100\%$$

$$= \frac{224 - 31.04}{224} \times 100\%$$

$$= 86.14\%$$

The DWWM's planned increase in the aeration capacity of the treatment system will result in improved BOD removal efficiency. In general, the relative improvement can be expected to be directly proportional to the BOD concentration present. For this case, a 4% increase in removal efficiency will be assumed.

The improved removal efficiency would then be:

$$E_{BOD}' = E_{BOD} \times (1 + delta_E)$$
$$= 86.14 \times 1.04$$
$$= 89.59\%$$

The secondary effluent BOD concentration resulting from this improved removal efficiency is:

$$S' = S_0 (1 - E_{BOD}') \qquad (6)$$
$$= 224 (1 - 0.8959)$$
$$= 23.32 \text{ mg/l BOD}$$

In general, a good relationship between SS and BOD levels is typically found for both influent and effluent in a given sewage treatment plant. On this assumption, the recorded effluent data for SS and BOD were used to develop (via simple linear regression) an equation relating the SS/BOD ratio to SS levels. The equation yielded is:

$$SS/BOD = (1.816 \times 10^{-3})(S') + 0.734 \quad (7)$$

Eq. (7) indicates that SS levels are typically lower than BOD levels for values of BOD less than 146 mg/l.

The SS/BOD ratio for the influent into the tertiary clarifiers can therefore be calculated by substituting S' (= 23.32 mg/l) into Eq. (5):

$$SS/BOD = (1.816 \times 10^{-3})(23.32) + 0.734$$

$$SS/BOD = 0.776$$

The SS level of the secondary effluent (i.e., influent into the tertiary clarifiers) can then be calculated using:

$$SS_{infl} = BOD_{infl} \times (SS/BOD) \quad (8)$$

where SS_{infl} = SS concentration of secondary effluent, i.e., influent into tertiary clarifiers, mg/l
BOD_{infl} = BOD concentration of secondary effluent, i.e., influent into tertiary clarifiers, mg/l
= S'

Substituting the previously obtained values for BOD_{infl} and SS/BOD into Eq. (8) yields:

$$SS_{infl} = (23.32)(0.776) = 18.10 \text{ mg/l SS}$$

To summarize the calculations up to this point,

BOD_{infl} = 23.32 mg/l BOD (secondary effluent, i.e., influent into the tertiary clarifiers)

SS_{infl} = 18.10 mg/l SS (secondary effluent, i.e., influent into the tertiary clarifiers)

In order to calculate the BOD and SS levels of effluent from the tertiary clarifiers, the levels of removal for both of these parameters within the tertiary clarifiers must be established. Removal rates for the specific polymer and treatment process to be used here are not available, however, and this makes it necessary to estimate removal rates by extrapolating from data for similar applications.

For this purpose, the Chemical Aids Manual for Wastewater Treatment Facilities (EPA, 1979) will be used to provide data which may be used as a basis for comparison (refer to Table I below).

From the SS data listed in Table I, a relationship expressing the removal of SS through the polymer addition/tertiary clarifier system is developed:

$$SS_{effl} = (0.2005)(SS_{infl}) + 6.05 \qquad (9)$$

Admittedly, it is undesirable to establish an empirical relationship on the basis of such limited data. Nevertheless, this approach was considered to be preferable to the only other available alternative; i.e., the use of an assumed removal efficiency that was not supported by any actual data.

Two other factors supporting this approach should be noted. First, SS (%) removals are generally directly proportional to the influent SS levels; the relationship between SS concentration (as the independent variable) and effluent SS concentration (as the dependent variable) would therefore be expected to be curvillinear in nature, and concave downward. The linear regression approach used here may therefore be considered conservative, as it predicts a higher effluent SS level than might typically be expected for the relatively high influent SS level present in this case.

Secondly, the high-molecular-weight polymers currently in use are considerably more effective than those in use at the time the data in Table I was taken. The SS removal efficiencies in this application would therefore be expected to be superior to those reflected by the EPA data.

Table I. Effect of Polymer Addition on Secondary Clarifier Performance (EPA, 1979).

Location	Type of Plant	Location of Polymer Add'n.	Polymer Type	Infl. SS (mg/l)	Effl. SS (mg/l)
Bloomington, Illinois	Activ. Sludge	Aerator	33.9 mg/l Fe^{3+} + 0.7 mg/l Purifloc -A23	12.7	8.6
	Trickl. Filter	Before Final Settling	25.3 mg/l Fe^{3+} + 0.5 mg/l Purifloc -A23	49.6	16.0

Therefore, using Eq. (8):

$$SS_{effl} = (0.2005)(18.10) + 6.05$$

$= 9.68$ mg/l SS (effluent from tertiary clarifiers)

This is less than the target value of 28 mg/l, and is therefore acceptable.

The removal efficiency of SS through the polymer addition/tertiary clarifier process is therefore calculated by:

$$E_{SS} = \frac{SS_{infl} - SS_{effl}}{SS_{infl}} \times 100\% \qquad (10)$$

where E_{SS} = SS removal efficiency through the polymer addition/tertiary clarifier system, %

Therefore,

$$E_{SS} = \frac{18.10 - 9.68}{18.10} \times 100\% \qquad (11)$$

$$= 46.53\%$$

It will be assumed that 70% of the BOD is insoluble in nature, with the remaining 30% of the BOD being soluble. This ratio is based on data from the Mililani WWTP, which is considered to treat wastewater with similar characteristics to that experienced by Whitmore Village WWTP. The BOD concentration in the effluent from the tertiary clarifiers can therefore be calculated by:

$$BOD_{effl} = (BOD_{infl}) \times [1 - (E_{SS})(.70)] \qquad (12)$$

where BOD_{effl} = BOD concentration in effluent from tertiary clarifiers, mg/l

Therefore,

$$BOD_{effl} = (23.32) \times [1 - (0.4653)(0.70)]$$
$$= 15.72 \text{ mg/l}$$

This is less than the 28 mg/l target level for BOD, and is therefore acceptable.

The BOD removal efficiency of the polymer addition/tertiary clarifier system can be calculated by:

$$E_{BOD} = \frac{BOD_{infl} - BOD_{effl}}{BOD_{infl}} \times 100\% \qquad (13)$$

where E_{BOD} = BOD removal efficiency through the polymer addition/tertiary clarifier system, %

Therefore,

$$E_{BOD} = \frac{23.32 - 15.72}{23.32} \times 100\%$$

$$= 32.57\%$$

Summary of Design Calculations:

Wastewater Flows

	EXISTING	NEW
Average Flow	0.16 MGD	0.211 MGD
Maximum Flow Factor	3.93	3.75
Wet Weather Infiltration/Inflow	0.15 MGD	0.16 MGD
Maximum Flow	0.63 MGD	0.79 MGD
Peak Flow	0.78 MGD	0.95 MGD

Wastewater Characteristics

	EXISTING	NEW
Influent BOD	224 mg/l	224 mg/l
Influent SS	184 mg/l	184 mg/l
Effluent BOD	20 mg/l	16 mg/l
Effluent SS	17 mg/l	10 mg/l
Mass Emission Rate (BOD)	22.71 kg/d	22.36 kg/d
Mass Emission Rate (SS)	22.71 kg/d	22.36 kg/d